IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
UTILITY PATENT APPLICATION

METHOD FOR PROBLEM FORMULATION AND FOR OBTAINING SOLUTIONS FROM A DATA BASE

BACKGROUND OF THE INVENTION

The process of innovation within organizations remains largely untouched by the general trend toward improved efficiency through automation. The traditional model of stimulating innovative thought is through the application of psychological techniques such as brainstorming. The techniques bring limited improvement to the process.

More recently, there have emerged a number of computer based technologies which can be applied by a researcher or designer who is considering the creation or improvement of a device, process, or other system. These technologies can be defined as problem analysis tools.

Problem analysis tools assist the user by enabling the user to consider a complex system and identify discrete problems which should be addressed. These tools accomplish this by providing computer based interfaces which assist in the application of well understood methods of problem analysis including, but are not limited to, root cause analysis, TRIZ, value engineering, function analysis, and system benchmarking. An example of such a tool, called TechOptimizer, is a computer system marketed by Invention Machine Corporation of Boston, Massachusetts. The technology used in TechOptimizer to assist in problem analysis is partially described in U.S. Patent No. 6,056,428 and U.S. Patent No.

6,202,043. The system disclosed in these two patents is fully described in TechOptimizer user guide, version 4.0, Invention Machine Corporation, Boston, Massachusetts.

The TechOptimizer software suite includes a module, which allows a user to build a functional model of the design and/or technological process, to perform value diagnostics of the design and/or technological process, identify a better (for example, higher value) configuration of the design and/or technological process, and identify what problem has to be solved in order to implement this new configuration.

The deficiency with problem analysis tools is that while they greatly aid in the identification of specific issues to be address, they do not provide solutions to the identified problems. This can be understood by considering the following illustrative example. Consider an engineer who is trying to simplify the design of a soap dispenser. Figure 1 illustrates a function model diagram of a soap dispenser which includes some scrubbing material. Figure 2 shows a modified version of the soap dispenser model reflecting an intended change to the design of the bottle which eliminates the scrubbing material, yet preserves the scrubbing function by delegating that function to the liquid soap. This alternative design contains a new engineering problem that must be resolved in order to validate that this design is achievable—how can liquid soap perform a scrubbing function? Figure 3 illustrates how a problem analysis tool might catalog and identify that problem for the engineer.

Once the problems have been identified, the user must conduct independent research using whatever means are available to find useful information. These means could include using books, public internet search engines, private data subscription services, internal enterprise portals, or other sources of relevant technical information.

BRIEF DESCRIPTION OF THE INVENTION

The present invention provides a method and system for using computer based systems to provide automated knowledge search capabilities in conjunction with problem analysis functions. In accordance with the principles of this invention, in one embodiment, problem analysis tools are augmented by the inclusion of knowledge search capabilities for databases, such that when a problem is identified, it is automatically re-formulated as a natural language or Boolean query to the databases, and responses to this query from the databases are automatically provided. In said embodiment, the machine representation of a problem statement generated by the problem analysis component is converted into a query appropriate to the available knowledge search technology. Different problem analysis tools will generate different specific machine representations, and similarly the target query format will vary with the knowledge search technologies applied. For example, a natural language query is suitable for search engines using semantic algorithms and a key word query for less sophisticated engines. There are a number of specific techniques which may be used to perform the mapping from a specific machine representation to a desired

query, such techniques consisting of the steps of extracting key elements from the machine representation of the problem statement and subsequently reformulating those extracted elements to form a properly formed query.

In particular embodiment of a tool that uses functional analysis, the problem statement is reformulated by translating a functional relationship into a natural language query. In another embodiment of a tool that uses root cause analysis, the problem statement is reformulated by translating a node statement into a natural language query.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1, 2, and 3 are illustrative screens in the commercially available systems for solving engineering problems;

Fig. 4 is illustrative screen for problem identification, search query, and for a search response in a system in accordance with the principles of this invention;

Fig. 5 is a high-level architecture diagram of one embodiment of a system in accordance with the principles of this invention;

Fig. 6 is a flow diagram of a system in accordance with the principles of this invention; and

Fig. 7 is an illustrative screen showing a problem analysis tool for root cause analysis.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS OF THIS INVENTION

Returning to the previously cited example illustrated by Figures 1, 2, and 3, with the system of the present invention, the problem analysis tool is augmented as shown in Fig 4 to automatically suggest possible solutions to the identified problems. Such an embodiment could possess a high level architecture as shown in Figure 5 comprising problem analysis tools 12, machine representations of problem statements 14, query formulation and submission 16, selected one or more knowledge search engines 18, and searchable databases 20. The system would facilitate a functional use model 22 as depicted in Figure 6 including the following steps: to perform analysis of a system and identify problems to solve 24; when a problem is identified, it is automatically re-formulated as a natural language or Boolean query to the (for example, semantically indexed) database 26; the re-formulated query is submitted to the knowledge search engine which implements searching of the database 28; and responses to this query from the database are automatically provided, 30 as shown in the Solutions window of Fig. 4

One embodiment of this invention uses technologies described in U.S. patent No. 6,056,428 and U.S. patent No. 6,202,043 to provide problem analysis capabilities. Other problem analysis tools could be used in an alternative embodiment. This includes root cause analysis tools, for example.

In accordance with the principles of this invention one embodiment introduces two elements to the problem analysis tools.

One of these elements is a knowledge search tool. Knowledge search tools (also commonly referred to as search engines or database query tools)

facilitate the efficient access to information stored in computer based database systems. When applicable, a knowledge search tool and a database to be searched by it are defined herein as a knowledge base. The user is able to locate relevant information by presenting a properly constructed query in an appropriate form (e.g. natural language or Boolean expression) to the knowledge search tool which searches the database and obtains results. The knowledge search tool responds to the entered query by constructing a result set comprising a list of information that meets the relevancy criteria imposed by the knowledge search tool. An example of such a knowledge search tool is a computer based system called Goldfire Intelligence marketed by Invention Machine Corporation, Boston, Massachusetts. The technology used in this tool is partially described in U.S. patent No. 6,167,370 The content of which is incorporated herein by reference

One embodiment of this invention uses the semantic indexing and search technology described in U.S. patent No. 6,167,370 for the purpose of performing knowledge searches. It will be apparent to the skilled practitioner that any other knowledge search tool could be used in an alternative embodiment.

The second element introduced to the problem analysis tools is a query formulator. In one embodiment, the machine representation of a function model is used as the source of key elements with which to build a query. For example, in Figure 2, the arrow labeled "scrub" which connects the system component labeled "liquid soap" to the system component labeled "hand" represents the need to find a mechanism by which liquid soap can be made to scrub hands. Referring to Fig 8, in this example, in one embodiment, the connecting arrow is

interpreted as a desired action (scrub) and the system component labeled "hand" is interpreted as the object of the desired action (these are displayed at "Problem Description"). Along with the graphical display of the problem description the Problems & Solutions portion of the screen provides proposed approaches to solve the problem. Using the functional relationship the system constructs the query "How to scrub the hand?" as a query to be submitted to the knowledge search tool by automatic reformulation by translating the functional relationship into a natural language query. The query is shown in the Solutions portion of the screen which also shows the several types of knowledge bases that are available to the user. These knowledge bases are resident in three possible places. One is on the user's own computer memory, or portable memory devices such as CDs that can accessed at the user's location. Another is called Corporate Knowledge which is typically on one or more servers resident or privately accessible to user's within the organization such as a corporation. Another is publically accessible search engines and databases such as Google (a search engine) and the U.S. Patent and Trademark Office patent collection (a searchable database). In one embodiment, an entry in the Problem & Solutions window will be automatically selected (or it can be programmed to allow the user to select) and similarly will automatically start the searching of the three categories of databases. The software allows configuration by a user to, for example, rewrite the Query, and to limit the search. As shown in Fig 8, the automatic (or user selected) search of all three categories is underway (see "searching" on the right side). In Fig 9 there is shown that searching is completed

with 3 relevant results in the Corporate Knowledge database, but no results in the other databases. Fig 10 shows the results of the search posted along with necessary links to access the results.

It will be apparent to the skilled practitioner that in alternative embodiments the specific mechanism for extraction of key query elements from a given problem analysis tool's machine representation will vary with the tool as will the mechanism for construction of the automatically formed query. For example, Figure 10 depicts a graphical representation corresponding to the results of using a problem analysis tool which automated the process of root cause analysis. In this situation, the result of the root cause analysis has a machine representation which is a directed graph wherein each node, a, b, c, of the graph represents a problem statement and each edge (shown as arrows connecting the nodes) of the graph represents a cause-effect relationship. In this case, the machine representation of each problem statement contains a well formed natural language fragment. Thus, if the user wishes to address the problem that the engine runs rough, since the user has the presumed goal of preventing the identified problem, by selecting the node a, "engine runs rough" the user gives the program an assignment to create the formulation of the query which it does by generating a statement of the form "How to prevent engine runs rough?", in which the node is translated into the query statement.

Since it is the case that relevant solutions to the problems identified through the use of a problem analysis tool often exist in the body of knowledge accessible via a knowledge search tool, this addition of these two new elements

to the problem statement tools present immediate and compelling benefits to the user. A new model of use is enabled wherein the operations of problem analysis and applied research are no longer disjoint activities. Now, a single operation is made available which allows users to dynamically find potential solutions to issues as they are identified. This results in greater productivity as the tradition latency between problem identification and solution concept feasibility and practicability analysis is eliminated.